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Woody Plants Species Diversity of Home Garden Agroforestry in three Agroecological Zones of Dilla Zuria District, Gedeo Zone, Southern Ethiopia

Yirefu Tefera, Wendawek Abebe and Bogale Teferi

Abstract
Trees, shrubs, herb and grasses are the basic components of the home garden agroforestry systems in Ethiopia and have been practiced for a long time. Hence, the aim of this study was to investigate woody plants species diversity of home garden agroforestry in three agroecological zones of Dilla zuria district in Gedeo zones. Quadrant of 20×20m was laid down in selected sample sites of the farm plots. Species abundance; numbers of individuals for each species and altitude data were recorded. From these plots a total of 3311 trees and shrubs belonging to 39 species of 35 different plant genera and 25 plant families were recorded. The most species rich families were Myrtaceae, Fabaceae, Rosaceae and Boraginaceae. Other plant species representing climbers and herbs were recorded growing together with trees and shrub s. TWINSPAN analysis identified two two plant association where *Mangifera indica* & *Psidium guajava* were indicator species for the first association and. *Eucalyptus globules* for the second association. The five most frequent tree species in Dilla zuria home garden AF systems were *Millettia ferruginea, Coffea arabica, Croton macrostachyus, Vernonieae amygdalina* and *Persea americana*. The species richness in Qolla, Weyna Dega and Dega was 24, 23 and 17, respectively. Qolla agroecology had high species diversity (0.84) as compared to Dega (0.71) and Weyna Dega area (0.68). The overall Shannon- wiener diversity and evenness of trees and shrubs species in the study sites were 0.74 and 0.56, respectively.

Keywords: Agroforestry, Agroecological zones, Home garden, Species diversity, Species richness

1. Introduction
Ethiopia is a country with different landscapes and one of the countries with the widest cultural diversities in eastern Africa (Negusse, 2006; Alemnew *et al*., 2007; Emiru *et al*., 2011) [13, 3, 7]. This diversity is the result of diverse topography and climatic conditions making the country an important center of diversity and endemism (Mekonnen, 2003) [11]. The richness and endemicity of the floral biodiversity have been reported by many researchers (Vivero *et al*., 2005) [19]. It is estimated that about 10% of flora is endemic (Ensermu *et al*., 1992) [8]. Out of these, the tree flora consists of an estimated 1100 species (Vivero *et al*., 2005) [19]. Tree planting was conceived as a potential strategy to meet the needs of the local people and protect the environment during 1970s (Bongers, 2010) [5]. The worldwide interest in tree planting and management gave birth to several popular terms with <forestry> ending such as social forestry, community forestry and Agroforestry. The latter system, Agroforestry (AF) is a collective name for land use systems and technologies involving where trees and shrubs combined with crops and animals in the same land management unit (Regmi, 2003; Mcneely and Schroth, 2006; Varadaranganatha and Madiwalar, 2010) [14, 12, 18]. The AF systems have been evolved with the development of mankind and many of these are socially acceptable, economically viable and biophysically sustainable. This kind of AF system has been an age-old practice in the Ethiopian farming system (Badege and Abdu, 2003; Kindeya, 2004) [4]. The existence of these systems has a great potential for further development and the introduction of new AF systems. However, many and diverse AF practices that exist in Ethiopia; and by no means do them represent an exhaustive list of systems and practices.
The Gedeo zone in Southern Ethiopia is one of the areas practicing ecologically sound land use system. Gedeo zone is also best known for its *Coffee arabica*, beautiful culture and scenery, and indigenous AF system that maintain the livelihoods of more than 3000 people per square kilometer in some places (SLUF, 2006) [15]. This AF system supported and will continues to support the rural community by serving as means of food, medicines, source of income and

building material for rural households. However, increasing population pressure in the area might have resulted in the depletion of forest resource affecting the system. And yet the rural communities in Gedeo zone largely depend on forest for their livelihood. Such activities would undoubtedly reduce the diversities of tree and shrub species in the study area eventually affecting the AF system. Plant genetic resources are one of the most valuable assets to mankind. Protection and conservation of these resources for use of generation, therefore, assume great significance and is a prerequisite for sound selection, breeding and conservation programs. There are no previous reports on the diversity of woody plants in Dilla zuria district home garden agroforestry (HGAF) systems particularly on patterns of distribution on the different agroecological zones. Therefore, this study was designed to determine diversity and vegetation structure out of woody plants species of HGAF in the three agroecological Zones (Kolla, Weyna dega and Dega).

2. Materials and Methods

2.1 Description of the study area

Dilla zuria woreda is located between 6º15′05″ N- 6º26′35″N latitude and 38º 15′ 55″ E and 38º 24′ 02″ E longitudes (Figure 1). It is bounded with Gelanabaya district of Oromia regional state in the south, Bule districts in the East and Sidama zone (Dara woreda) in the north. It is divided in to 19 kebeles. Woredas altitudinal range covers from 1350m to 2550m with slope from 39.4% to 51.5%. It is drained by several medium and small streams such as Dara, Walame, Sala and Deninnka. In the area temperature ranges between 15 ºC to 35 ºC and rainfall between 1000mm to 1400mm. The woreda contains Dega (23%), Woynadega (70%) and Qolla (7%) agroecological zones of which 15 kebeles within Woynadega, 2 kebeles within Dega and also 2 kebeles within Qolla. There are four types of soils in the area i.e. eutric cambisols, chromic luvisols, eutric nitosols and chromic vertisols. According to the 2007 population census the total population number of Dilla zuria was 97,327 (Zonal Statistical Abstract, 2010) [21].

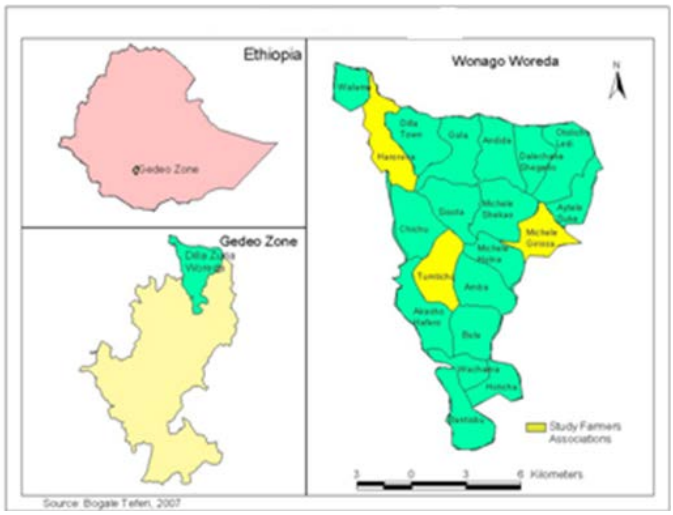


Fig 1: Location of the study area

Table 1: Description of the study area

Agroecology	Total area (m^2)	Temperature (C°)	Annual Rain fall (mm)	Alt. (M)	Area (coffee)	Area (enset)
Harroresa kebel (Qolla)	640 ha	15-27	750-1150	1350-1500	350 ha	233 ha
Tumiticha kebele (Weynadega)	880 ha	13-18	1150-1350	1550-1750	550 ha	20ha
Michile greesa (Dega)	800 ha	10-14	1500-2000	1880-2500	5 ha	680 ha

2.2 Sampling techniques and data collection methods

2.2.1 Sampling Method

Three main agroecological zones are recognized in Ethiopia, based on altitude: Dega (2300-3200m), Woyna Dega (1500-2500m) and Qolla (500-1500m) (Zemede, ND). Dilla zuria district was considered as a unit, in which, three distinct agroecological situations were identified. Purposive sampling method was used to select the sample in each of the distinct agroecological situations. The sites were identified using topographic maps (1:50,000) and satellite images (ETM^+, 2000). In each agroecological situations, one kebele namely *Harroressa* (Qolla), *Michile Grisa* (Dega) and *Tumiticha* (Woyna Dega) were selected purposively based on the extensive presence of HGAF. A total of fifteen (15) villages; five (5) from each agroecological situation were identified. Selection was based on the relative location of the villages. Thus, four villages from borders and one from the center were selected. Fifteen respondents who have integrated trees and shrubs in their AF system were selected among list of farmers by laid down quadrants in their home garden. The rest fifteen old and knowledgeable key informants were systematically selected and interviewed about indigenous knowledge of the system application. This was done by taking the consideration that not all informants have equal knowledge about plant uses. The data on species diversity, species density, and distribution patterns of dominant tree/shrub species in HGAF systems were collected through field observation, semi- structured interview and quadrant analysis prepared for the purpose.

2.3 Data collection

To assess the diversity and the composition of plant species in the home garden, three sample plots 20×20m (400 m^2) were laid down in each village. The first plot was randomly selected and the second and the third plot were systematically selected in order to cover all species typing occurring in the garden, totally 45 sample plots (Abiot and Gonfa, 2015) from randomly selected farm land owner (15 from each village). All trees and shrubs plant species in each plot were counted, collected and dried. Collected plant specimens' later were taken to the national herbarium made by comparing them with the specimens already identified on Herbarium and using published accounts of the Flora of Ethiopia and other taxonomic works of neighboring countries. Environmental attributes such as altitude, location etc were recorded during the expedition using GPS (Global Positioning system).

2.4 Data analysis

Vegetation data and percentage cover on plant species composition were transformed to Ordinal Transformed Values

(OTV), and analyzed using a [FORTRAN computer], TWINSPAN program, Two-way INdicater Species, Version1.0. SPSS version 20 and Microsoft excel 2007 were used for the analysis of descriptive data such as mean and standard deviation. Frequency, mean and percentage will be used as tools for summarizing the data. Both species diversity and equitability (evenness) relative abundance were calculated using Shannon diversity (H) and Evenness (J) indices, respectively. Ordination analysis was carried out by using statistical software PAST (Paleontological STastics) to study the relation between altitude and species.

3. Result and Discussion

3.1 Floristic composition in Home garden Agroforestry

A total of 52 species were recorded in the study site. The home garden species of the study sites can be grouped in four life forms; trees, shrubs, herbs and climbers (Figure 2). Out of these 52, 39 species were woody plants belonging to 35 genera and 25 plant families (Table 2). Among the recorded 39 species, 33 (86%) were found to be trees and 6 (14%) were shrubs. The remaining thirteen species represent herbs and climbers. These include: *Ensete ventricosum, Dioscorea alata, Dioscorea cayenensis, Dioscorea abyssinica, Ipomoea batatas, Musa acuminate, Hoddeum vulgaris, Triticum aestivum, Annanas comosus, Colocasia esculenata, Vicia faba, Brassica oleracea and Allium sativum.* These plants are mainly grown in association with trees and shrubs in the Gedeo HGAF system. Most of plant species which are found in the studied home garden were frequently cited in other related studies. For example, *Persea americana, Cordia africana, Coffee arabica, Mangifera indica, Millettia ferruginea, Catha edulis, Ficus vasta, Psidium guajava* (Abreha and Gebrekidan, 2014) [2], *Cordia africana, Coffee arabica, Mangifera indica, Persea americana (*Ewuketu *et al*., 2014) [9]. Among the 25 families recorded in area 9 families are represented by more than one species. Out of these Myrtaceae is represented by 4 species followed by Rosaceae, Fabaceae and Moraceae, each represented by 3 species. The remaining 16 families' were represented by a single species. Myrtaceae is the dominant family in terms of species richness. It's dominancy mainly contributed by *Eucalyptus* species. Most of the people who live in rural Ethiopia including this study site usually use *Eucalyptus* for construction and as fuel wood. And this might explain the dominance of the family Myrtaceae. Similar studies in different parts of Ethiopia reported comparable results. To mention some: A study in Jabithenan district in Ethiopia by Ewuketu *et al*., 2014 [9] identified 69 plant species (44 woody and 25 herbaceous) and Abreha and Gebrekidan, 2014 [2] from south Gonder, Ethiopia reported 26 trees. A study by Tesfaye, 2005 [17] (in the neibouring districts of Sidama zone reported a total 120 species of trees and shrubs.

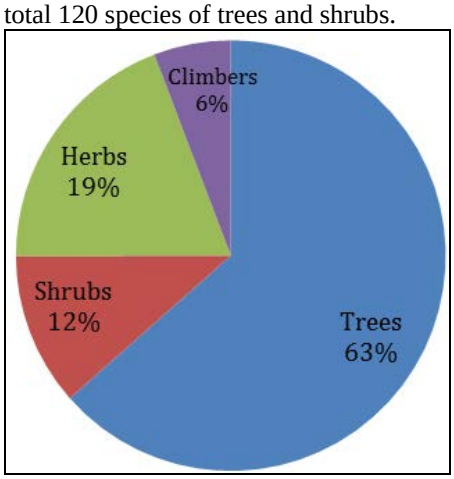


Fig 2: Proportion of overall woody and herbaceous species of HGAF in Dilla zuria district

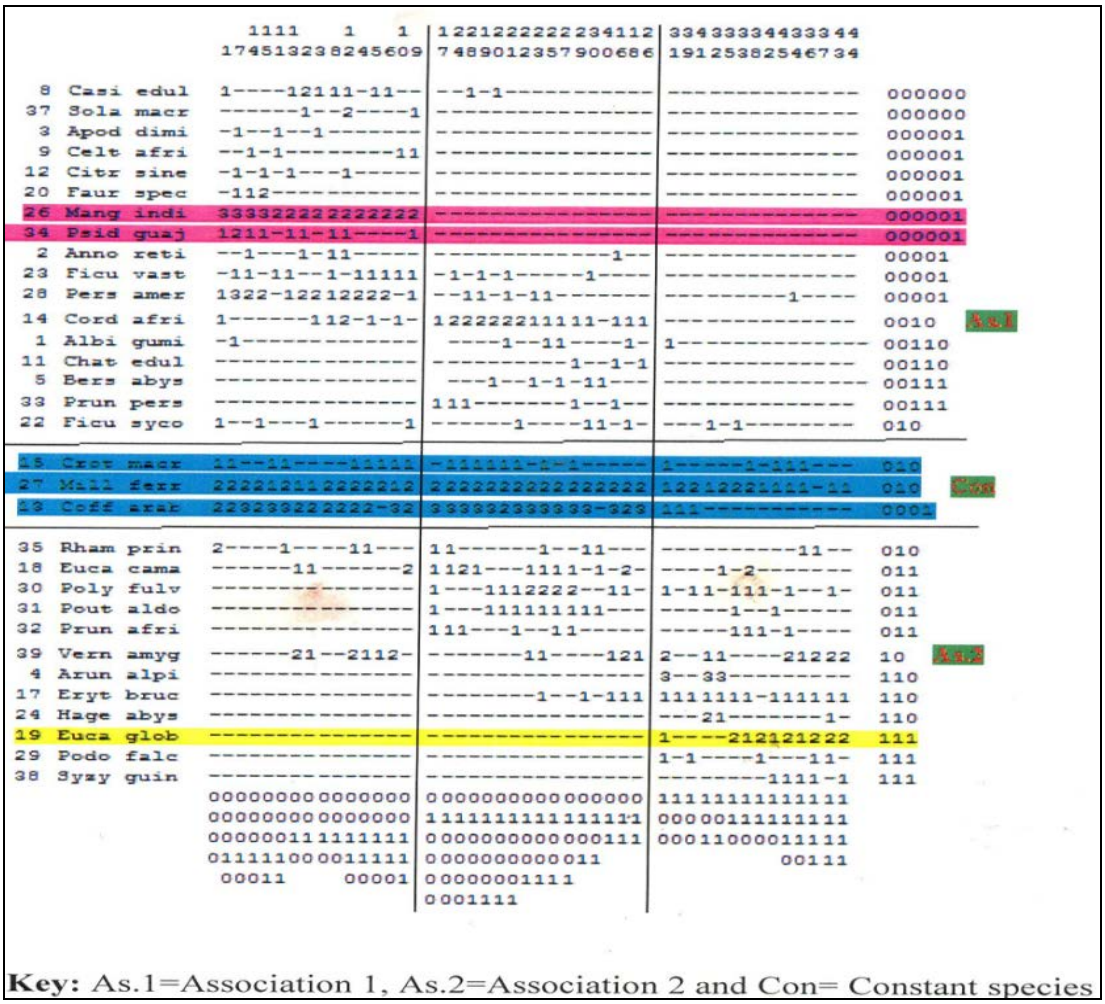
Table 2: List of the plant families identified in the study area with the number of genera and species representing each family.

No	Family	No of genera	No of species	Proportion (%)
1	Myrtaceae	3	4	10.2
2	Rosaceae	2	3	7.6
3	Moraceae	1	3	7.6
4	Fabaceae	3	3	7.6
5	Euphrbiaceae	2	2	5.1
6	Boraginaceae	2	2	5.1
7	Rutaceae	2	2	5.1
8	Rubiaceae	2	2	5.1
9	Ulmaceae	2	2	5.1
10	Araliaceae	1	1	2.6
11	Asteraceae	1	1	2.6
12	Sapotaceae	1	1	2.6
13	Poaceae	1	1	2.6
14	Melianthaceae	1	1	2.6
15	Solanaceae	1	1	2.6
16	Icacinaceae	1	1	2.6
17	Rhamnaceae	1	1	2.6
18	Lauraceae	1	1	2.6
19	Annonaceae	1	1	2.6
20	Myrsinaceae	1	1	2.6
21	Anacardiaceae	1	1	2.6
22	Proteaceae	1	1	2.6
23	Celastraceae	1	1	2.6
24	Podocarpaceae	1	1	2.6
25	Meliaceae	1	1	2.6
Total		33	39	100%

3.2 Plant community association

The output of the TWINSPAN in the form of two ways table diagram is shown in Table 3. For the purpose of analysis, species were coded with four letters and in the final analysis the thirty nine woody plant species and 45 sample plots were considered. From the analysis two associations were identified. These associations were considered as the representative plant communities in the study area. The result of ordered two-way table from TWINSPAN illustrates that the species on the top are more abundant on the left side of the primary division than on the right side. The species on the bottom are more abundant on the right side of the primary division than on the left side. The species in the middle are constant, occurring widely on the both sides. In all the association, species with high indicator values are those that were easily observed repeating themselves in association. Accordingly two species, *Mangifera indica* and *Psidium guajava* were found to be indicator species used to differentiate the group of samples to the left of the primary division (''Association 1''). This association includes trees such as *P.americana, F.vasta, F.sycomorus, C.africana, B.abyssinica, A.reticulata, Faurea speciosa, P. persica* and others. As we can understand from above result, the association is more of fruits. On the other hand a *Eucalyptus globule was* found to be an indicator species for the right side of the primary division ("Association 2"). This association includes trees such as *E. globules, R. prinoides, P. fulva, E. brucie, P. africana, V. amygdalina, P. falcatus, A. alpina, E. camaldulensis, H. abyssinica, S. guineense* and *P. aldolfi-friederic*. As we can understand from above result, the association is more of woody plants. *M. ferruginea, C. arabica* and *C. macrostachyus* were found to show a wider distribution and are called constant species.

Table 3: Two–way table of plant association in the home garden of Dilla Zuria district.



3.3 Characterizing of the Study Area

In the present investigation, there was considerable variation among the three agroecological zones in Dilla zuria district with respect to HGAF practiced by farmers. Spatial arrangement of HGAF is not consistent at the study site. That is most of HGAF is located in the backyard while a few are located on the side of the home. During the study, three major plant components in the HGAF were identified (table 4).

These are

1. The major Agroforestry system in Qolla agroecological zone is *coffee-fruit crops- tree*. In this area highest species richness was recorded. This result could be associated with 1) moist and warm climate 2) the practices of planting different multipurpose trees which are used as coffee shade 3) fruit trees are very common in this agroecology compared to dega and woyna dega agroecology. For example, Harroressa kebele (from Qolla area) have small area of land relatively compared to other kebeles (see table 1). To get full benefit from their farmland, the farmers might have accommodated higher number of tree species or densely planted within the limited area as ecological conditions favor the growth of more number of tree and shrub species. Therefore, this agroecology relatively diversified and better conserved compared to the other agroecologies.
2. In Woyna dega agroecolgy mainly is practiced *Enset-Coffee-Tree system*. Coffee is the major source of income for the household in the area associated to enset (*Ensete ventricosum)* (Ganticho is the name of the enset in Gedeo zone or Kocho). Enset provide source of food, coffee for income /cash/, boyena and godere supplement the household food consumption. Since the farmers' are selective; they conserve few trees in their farm for purpose of shading, fuel and construction. Even different trees grown in their farm but most of them are rare; that is the area is dominated by coffee. Therefore, the high abundance of *Coffee arabica* is attributed to increase planting every year since it becomes the main source of the Gedeo's economy.
3. Compared to Qolla and Woyna Dega agroecology, Dega have less number of species (richness) which is mainly dominated by enset and having few tree species. Therefore, the major Agroforestry system is *enset-tree* system. Enset crop is the main source of food and everything to farmers. It has economical, cultural and environmental benefits. But original vegetation of this area was composed of tree species such as *Podocarpus falcatus*, *Syzygium guineense*, *Millettia ferruginea*, *Cordia africana*, *Croton macrostachyus*, etc. Due to expansion of the Agroforestry systems; farmers started clearing all existing vegetation by retaining few scattered trees species based on economic and ecological benefits. On the other hand, different reports suggest that species diversity and richness decrease with increasing altitude (Tesfaye, 2005; Shimono *et al*., 2010) [17, 22]. For example, in present study the temperature ranges of dega agroecology between 10-14 °C (Table 1), relatively less than the other two agroecology. This might not be suitable for the growth of most tree (fruit trees) species which are common in Qolla and weyna dega agroecology. Moreover the system of Agroforestry depending on farmers' interest that means farmers' knew which type of trees and shrubs associate to which kind of crops. Since in the area there is no more coffee plantation (Table 1), no trees are planted for the purpose of shading. Even for the purpose of construction they use *Eucalyptus spp*. and the leaf of Enset. In addition most people in this area rear livestock, where people prefer grazing land for their livestock. Hence, this agroecology have less species richness depend on above mentioned factors.

Table 4: Major plant combination in HGAF system

HGAF	Qolla agroecology	Woyna dega agroecology	Dega agroecology
	Coffee-Fruit crops- Tree	*Enset-Coffee-Tree*	*Enset-Tree-*

3.4. Woody Plants Species Density and Richness

Farmers in the study sites retain various trees and shrubs based on space availability and their compatibility with agricultural crops. The total density of woody plants in the study site was 3311, ranged from 1282 for weyna dega, 1253 and 776 for Qolla and dega agroecology, respectively. The average number of trees and shrubs per farm plots in the study site was founded to be 8.4. The tree and shrub density per plot was (9.7) in Qolla area followed by Woyna dega (9.3) and Dega (6.3) (table 5). These results are contradict with the findings of Varadaranganatha and Madiwalar (2010) [18] reported that the tree density per hectare was much higher (53.70) in higher elevation area and coastal area (38.70) than lower elevation (23.45) area. In the present study, the majority of farmers in Woyna dega and Qolla area have small and marginal land holding (Table 1). To get fullest benefit from their farmland, they might have accommodated higher number of tree and shrubs species within the limited area. Species richness was also higher in Qolla area (24) followed by woyna dega (23) and less for dega area (17).

Table 5: Species richness, Species density and Standard deviation of plant species.

Agroecological situation	Species richness (Total number)	Species density (mean per 400m^2)	Standard deviation (SD)
kolla (n=15)	24	9.7	1.39
W/dega (n=15)	23	9.3	1.4
Dega (n=15)	17	6.3	1.5
Total (n=45)	39	8.4	1.4

3.5. Species diversity indices

In order to get better picture about woody plant diversity in the homegarden, various diversity indices were calculated for each agroecology. The result indicated that, Qolla agroecolgy (2.00) had the highest species diversity followed by dega (1.7) and woyna dega (1.6) (table 6). Based on the above result, Weyna dega agroecolgy has relatively low species diversity as compared to dega. This might be due to tendency of the farmers to plant and maintain mainly *Coffee arabica* (the most important cash crop) on their garden. It was found that species are more equally represented in dega agroecogy (J= 0.6) compared woyna dega (J= 0.5) (table 6). The overall Shannon-wiener diversity and evenness of trees and shrubs species in the study area were 1.8 and 0.56, respectively (table 6). This

means that the relative homogeneity of the species in the samples is 56% of the maximum possible even population. Shannon-wiener diversity index ranged from a minimum of 1.5 (for woyna dega) to a maximum of 2.00 (Qolla). A similar study by Abreha and Gebrekidan (2014) [2] across niches of Woredas in southern Gonder, reported that Dera (woyna dega) is more diversified in home garden niche compared to Taqchgaint (dega) and Andabet (Qolla).**Table 6:** Species richness, diversity index (H') and evenness (J) of plant species.

Agroecological zones	Richness	Diversity index (H')	Evenness (J)
Qolla	24	2.00	0.6
Weyna dega	23	1.6	0.5
Dega area	17	1.7	0.6
Total	39	1.8	0.56

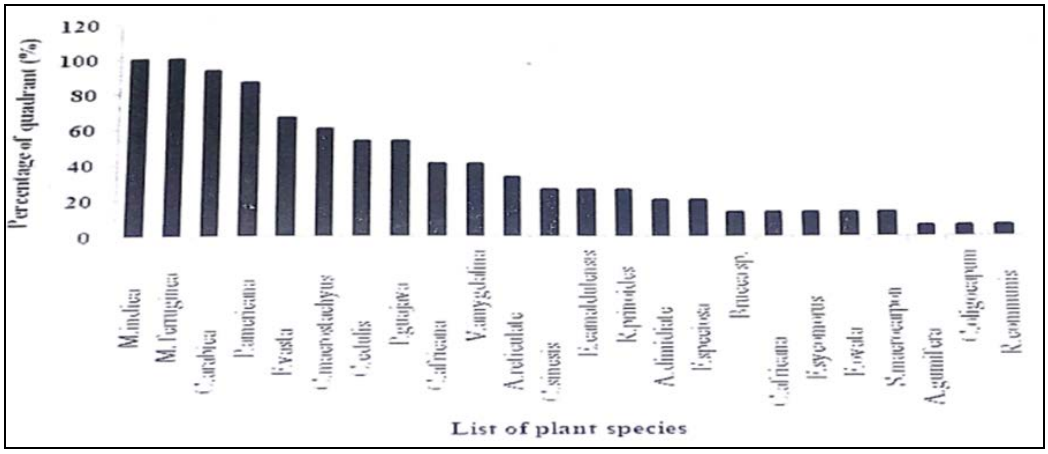
3.6. Floristic heterogeneity

Floristic heterogeneity could be expressed in terms of frequency of occurrence of a particular species in each quadrants of the study area. Accordingly, in the present study *Mangifera indica* with frequency of occurrence (100%) and *M. ferruginea* (100%) were found to be the most dominant species in kolla area (figure 3) followed by *Coffee arabica* (93%) and *Perea americana* (86.7%). This figure is in line with reports by Varadaranganatha and Madiwalar (2010) [18] from Indian homegarden in which *Mangifera indica* is the dominant fruit tree in the lowland area. This is due to its wider adaptability and ability, produce multiple fruits per tree. Similar to the above result, mango is a common fruit tree in the present area which is used as a source of income. *M. ferruginea* is also the most dominant tree used as shading for coffee plantation. *M. ferruginea* would decompose at faster rate and feed nutrients for the root suckers even as the farmers said the leaves of *Millettia* can easily decomposed that is why they used as natural fertilizer.

In Weinadega agroecology zone *Coffee arabica* (100%), *Cordia africana* (100%) and *Millettia ferruginea* (100%) were found to be the most dominant species followed by *Polyscias fulva* (66%), *Eucalyptus camaldulensis* (60%) and *Pouteria alnifolia* (60%) (Figure3). Coffee is the major cash crop used as the main source of income, which indicates the significant role of *Coffee arabica*, as reported in HG studies in Gedeo zone and other regions by (Tadesse, 2002; Tesfaye, 2005; SLUF, 2006) [16,17,15]. Therefore, coffee seedling is planted under shade of *Millettia ferruginea*, *Erythrina abyssinica*, *Cordia africana* and *Polyscias fulva* to serve as shade and source of organic matter. Farmers' preferred the plant species because of their socio-economic benefit than the other recorded species.

Table 7: Frequency distribution of woody plants in the HG of the study area (Freq. = frequency, % FR= Frequency percent
*Spps are arranged in descending order of Fr

No	Botanical name	Freq.	%FR
1	*Millettia ferruginea*	44	97.8
2	*Coffea arabica*	32	71.1
3	*Croton macrostachyus*	22	48.9
4	*Persea americana*	19	42.2
5	*Vernonieae amygdalina*	19	42.2
6	*Erthrina brucie*	18	40
7	*Eucalyptus camaldulensis*	18	40
8	*Polyscias fulva*	18	40
9	*Mangivera indica*	16	35.6
10	*Ficus vasta*	14	31.1
11	*Pouteria alnifolia*	12	26.7
12	*Cordia africana*	11	24.4
13	*Casimiora edulis*	10	22.2
14	*Prunus africana*	10	22.2
15	*Rhamnus prinoides*	10	22.2
16	*Eucalyptus globules*	9	20
17	*Ficus sycomorus*	8	17.8
18	*Psidium guajava*	8	17.8
19	*Albiza gumifera*	6	13.3
20	*Annona reticulate*	6	13.3
21	*Bersama abyssinica*	5	11.1
22	*Podocarpus falcatus*	5	11.1
23	*Prunus persica*	5	11.1
24	*Syzgium guineense*	5	11.1
25	*Citrus sinesis*	4	8.9
26	*Apodytes dimidiate*	3	6.7
27	*Arundinaria alpina*	3	6.7
28	*Chata edulis*	3	6.7
29	*Faurea speciosa*	3	6.7
30	*Hagenia abyssinica*	3	6.7
31	*Ricinus communis*	3	6.7
32	*Celtis sp.*	2	4.4
33	*Celtis africana*	2	4.4
34	*Brucea sp.*	2	4.4
35	*Ficus ovate*	2	4.4
36	*Solunum macrocarpon*	2	4.4
37	*Canthium oligocapum*	1	2.2
38	*Ehretia cymosa*	1	2.2
39	*Maesa lanceolata*	1	2.2
	Total	45	100%



Species are arranged in descending order of frequency

Fig 3: Frequency of occurrence of the species across the farm in Qolla (n=15)

3.7. Pattern of species distribution

The pattern of species distribution was assessed by plotting frequency classes versus the percentage of species belonging to each frequency classes. The result indicated that most of the trees and shrubs species recorded (61.5%) in the study area belong to frequency class A (with frequency of occurrence (0-20%). The remaining species were distributed in class B and C, 25.6%, 7.7%, respectively. Whereas the least number of species were recorded for frequency class E (2.6%) and class D (2.6%). Thus only a few number of species such as *Millettia ferruginea* and *Coffee arabica* were found in all the three agroecological zones studied (figure 4). In this regard our study revealed low percentage of species in the higher frequency class indicating difference in species distribution pattern across the farm plots in the three agroecological zones studied. The frequency of occurrence of all plant species in the three agroecological zones was also analyzed (see table 7). The result indicated that out of 45 sample plots *Millettia ferruginea* was recorded in 44 sample plots (97.8%), followed by *C. arabica* in 32 sample plots (71.1%), *Croton macrostachyus* in 22 sample plots (48.9%), and *P. americana and Vernonieae amygdalina* both occur in 19 sample plots (42.2%) followed by others species.

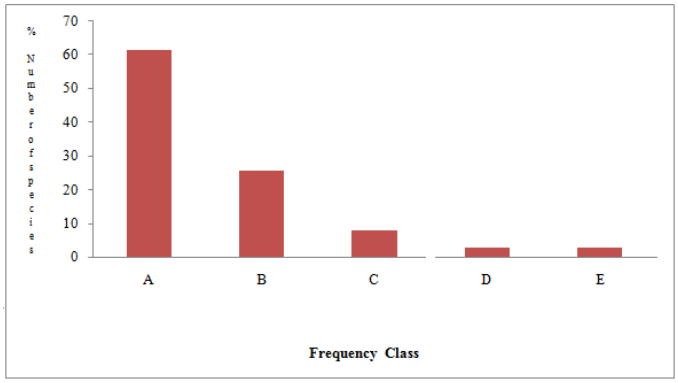


Fig 4: Frequency distribution of the woody plant species across the farm plots (n=45).
Where: A) 0-20, B) 21-40, C) 41-60, D) 61-80, E) 81-100.

The dominance of these species could be associated to their higher socioeconomic and or ecological roles in the farming systems. This finding is in line with the reports by Ewuketu *et al.* (2014) [9] which show that, species with multiple uses showed higher IVI (Importance Value Index) value. On the other hand, 3 tree species (*Canthium oligocapum, Ehretia cymosa* and *Maesa lanceolata*) were found to be very rare each occurred only in one of the farm plot. In general, *Millettia ferruginea* was found to be the most dominant tree species in all the three agroecological zones studied. This could be associated with its importance in improving soil fertility, for its light coffee shade, provision of fodders and fuel wood; hence the farmers prefer this tree and maintain it in their farm plots.

3.8. Relationship between altitudes in species richness

Altitude is an important factor in habitat diversity because it presents changes in the availability of resources, such as heat and water (Shimono *et al*., 2010) [22]. Data provided evidence from present study; altitude had significant effects on total species richness, composition and diversity. This trend could be affected by the outlier, that is few species are highly dominant, can restrict the overall diversity of the study area. For example, woyna dega agroecology of present area, coffee highly dominant through that species area not evenly distributed. This situation can restrict species diversity comparing to dega agroclimate. Ignoring above outlier, this study identified that tree and shrubs have negative relation with altitude range i.e. that diversity of tree decreases with increasing altitude, r= -0.3098 (Figure 5). Similarly, shrubs diversity decrease with increasing altitude range, r=-0.35167 (Figure 6). Depending on this diversity of species increases with increases amount of rain fall and temperature for humid lowland areas which are very rich in species as compared to other ecological zones. Whereas altitude increase there is high rainfall and minimum temperature which restricts plant growth.

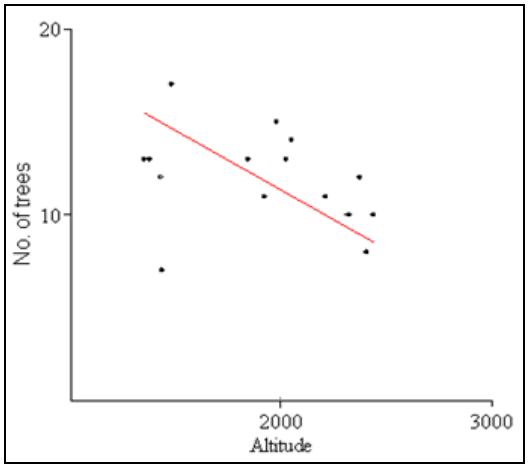


Fig 5: Relationship between number of trees and altitude of the study site.

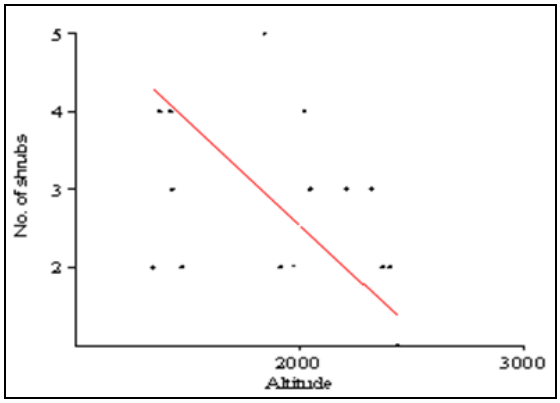


Fig 6: Relationship between shrub diversity and altitude of the study area.

3.9. Economic important of selected tree in the study site

According to the information obtained from the agricultural bureau of Gedeo zone, about 40% of the total coffee produced is for home consumption. It is used as a main cash crop in *Weyna dega* area. Drinking coffee is part of the social gathering among neighbors. One of the best and highest priced *arabica* coffees of the world, Yirga-chaffe, comes from the Gedeo highlands. It is the world most traded goods including our country Ethiopia. Because of the wide importance attached to the three tree species in their major roles are separately presented here. This is supported from different researchers stated about important tree species in the Agroforestry system. For example, the farmers' through experience knowledge, working trees are selected for various purposes such as purpose of shading (Damel and Assefa, 1991) [6] and soil enrichment or for fuel wood. *Ficus sp, M. ferruginea***,** *C. africana, E. abyssinica* and *P.fulva* are used for their soil maintenance and restoration. Most of the trees are fast growers, easily propagated and tolerant of regular pruning, and their leaves are easily decomposed. Farmers have well founded ingenious knowledge to manage each components of the system this is because soil fertility is gained from those plant different vegetation parts without using any processed products. Farmers, of course, selected the trees for these benefits. Therefore, based on the data obtained from farmers' preference, three the major trees are identified for many purposes. These are *M. ferruginea***,** *C. africana* and *Ficus spp.*

3.10. Perception of Agroforestry by the people in the study area

The survey conducted from different households in the study sites revealed that vegetation cover changes have occurred through time. For example, one of the key informants expressed his concern about the vegetation cover changes of the area in the following context.

"In previous time Gedeo zone was found densely covered by natural forest. This forest gradually changed to present Agroforestry systems. Although natural forest had declined, we have a long standing tradition of maintain trees in our farm lands. He said that because we know how much trees are important to our agricultural system, so we usually maintain and respect plants which have ecological role as well as economic value".

Similar responses were obtained from most of the other respondents. This might indicate that people in the study area have great awareness about the economic and environmental benefits of Agroforestry practices. Most of the respondents believe that an Agroforestry practice is high in terms of increased soil fertility and enhance the overall productivity. The simultaneous production of fodder, crop and vegetable and livestock contributes to increase in the overall household income. Maintenance of mixed trees on the farmland made households resilient to cope up with uncertainty and risks. The respondents strongly agreed that Agroforestry practices improved surrounding condition of the forest. However, they disagreed on the statement that takes long time to get income from Agroforestry practices.

4. Conclusion and Recommendation

Fifty two plant species were recorded in the study site. Among these thirty nine are woody plants (trees and shrubs). Those species belongs to 25 families where family Myrtaceae is represented by 4 species followed by Moraceae, Rossaceae and Fabaceae each represented by 3 species. And the others are herbs and climbers which are mainly grown in association with trees and shrubs in the Gedeo HGAF system. TWINSPAN analysis identified two representative plant associations in the study area which are *Mangifera indica* and *Psidium guajava* as indicator species for the first association and *Eucalyptus globules* an indicator species for the second association. The five most frequent tree species in Dilla zuria home garden AF systems were *Millettia ferruginea, Coffea arabica, Croton macrostachyus, Vernonieae amygdalina* and *Persea americana*. Species richness was higher for Qolla area (24) followed by woyna dega (23) and less for dega agroecology (17). During the study, three major plant components in the HGAF were identified. These are *Coffee-fruit crops- tree, Enset-Coffee-Tree system* and *Enset-Tree.*

The Gedeo Agroforestry system is relatively rich in biodiversity. However, the farmers are selective in their farm management system. This lead to some plant species is dominant while others are rare depending on their needs. Based on the result of this study the following recommendations were forwarded.

1. Gedeo's people used to maintain their traditional agroforetry system. With regards to tree and shrub flora in the highlands (Dega), the indigenous species have largely been replaced by a few exotic species, like *Eucalyptus spp.*, but they cannot provide such wide variety of products and services as do indigenous trees. For example, *Croton macrostachyus* is highly destroyed by the farmer's because they perceived that

the plant is dangerous for their coffee production. Perhaps, *Croton macrostachyus* may not be suitable for crop productivity, but may have other significance in the ecosystem even at least as it is indigenous plant for Ethiopia. Thus, the farmers should grow this plant on the marginal area or outside the production of perennial coffee production for the sake of maintaining the ecosystems. In addition *Podocarpus falcatus* (Zigba) and *Hagenia abyssinica* (Kosso) are endangered plant species. Due attention should be given for the prevention of indigenous plant species within the ecosystem. Promotion shall be done on planting and maintain indigenous trees.

2. Frequent training and awareness creation campaigns shall be conducted so that the local community will be well aware of the importance of Agroforestry system for his/her livelihood and environment.

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